1966

The effect of specified training intensities on cardiorespiratory adaptation

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THE EFFECT OF SPECIFIED TRAINING INTENSITIES

ON CARDIORESPIRATORY ADAPTATION

By

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B. A. University of Tulsa, 1965

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

UNIVERSITY OF MONTANA

1966

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

JUN 7 1966

Date

ACKNOWLEDGEMENTS

The author wishes to express his gratitude and appreciation to Dr. Brian J. Sharkey for his guidance and assistance during the completion of this study.

Appreciation is also expressed to the subjects for their cooperation and help. The author also wishes to thank especially his wife Donna, for her help and patience.

J.P.H.

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CHAPTER I

THE PROBLEM

I. Introduction

It is an accepted fact that exercise repeatedly carried out leads to an improvement in physical performance. Many studies have been conducted to measure cardiovascular endurance and the effects of training on the heart rate. Although the treadmill has often been used for physiological experiments, functional tests, and numerous analyses of level and grade walking, few attempts have been made to study the effects of training at various heart rate levels in graded walking and its effect on physical fitness.

Studies have been conducted to obtain more information about how the body reacts to training and conditioning. By way of experimental studies, Bobbert (3) found that there was no difference between walking on level ground and on a motor-driven treadmill. His work helped to substantiate the use of the treadmill as a controlled means of training.

More investigations need to be done concerning the use of a submaximal heart rate level at which to train for endurance. Several studies have been interested in all-out efforts for improved performance in physical exercise. Moncrieff (13) and Patton (14) conducted studies on endurance training using all-out, interval, and submaximal methods to see which method of training elicits the best results. Brouha has stated that studies should be made to determine what are the best training methods for physical activity and how the intensities and the durations of daily exercise should be varied. Brouha further stated that the use of the submaximal, distance running approach to high level endurance has been displaced as the best method of training by the use of high-intensity interval training methods (9). The question arises as to what level of training would be needed to elicit the desired fitness level. If we can obtain the desired result from training at a level of 160 beats per minute, it will not be necessary to train at the high-intensity level of 180 heart beats per minute.

II. The Problem

Statement of the Problem

The purpose of this study was to determine the effects of treadmill walking at varying grades on endurance and from this to determine if exercise at a level other than that evoking a maximal heart rate could be used to increase substantially one's physical fitness. Fitness, as used in this study, refers to cardiorespiratory fitness rather than strength, agility, or flexibility.

Significance of the Study

It is a well known fact among physical educators that strenuous effort is necessary for improvement in cardiovascular endurance and physical fitness. A number of studies have been conducted in areas pertaining to cardiac output during exercise of graded intensity and in the various adaptations of the cardiorespiratory system. On the basis of empirical evidence, coaches and physical educators have stressed the need for rather intense effort in order to obtain a high level of cardiorespiratory endurance.

There have been few studies conducted concerning the use of a submaximal heart rate level at which to train. If a high level of physical fitness could be reached without training at a maximal level, those in physical education, coaching, recreation and rehabilitation would be better able to prescribe the nature and intensity of exercise necessary to evoke such changes.

Limitations of the Study

1. The number of subjects was limited to sixteen, including four in the control group.
2. There was no way to enforce the regulations concerning sleep, diet and exercise.
3. The health habits of the subjects were not controlled; however, all were asked to refrain from any physical activity other than daily

walking to classes.

4. The length of the study was limited to sixteen training sessions in a six-week period. The study was interrupted for one week due to the Thanksgiving holiday.

CHAPTER II

RELATED RESEARCH

There has been considerable interest in physical conditioning and training for many years. Through regular exercise, the body becomes adapted to increased activity and changes take place which cause improvement in one's physical ability. To understand better the effects of various types of training, exercise physiologists have conducted research on varying aspects of the human body's response to exercise when done in a routine manner.

Maxfield (12), in a study conducted to measure cardiac performance as a result of endurance training, found that adequate training had an effect on the heart rate by an increase in work performed per heart beat and a decrease in heart rate during a set amount of work and at rest. This indicated that with training the heart became more efficient and reduced the heart rate response to work.

Patton (14), investigated the effects of two types of endurance training, all-out and interval. In his study, three groups were trained for eight weeks in programs consisting of all-out, interval, or no training on a treadmill. The results showed the two training groups had increased significantly more than the control group, but there was no significant difference between experimental groups.

A study on endurance training was conducted by Knehr, Dill and Neufeld (10) to determine if a change in capacity for work could result from training. Their subjects trained three times per week for six months on a track doing middle-distance running. The subjects underwent work experiments bi-weekly in which they walked for eight minutes on a motor-driven treadmill at three and one-half miles per hour on an 8.6 per cent grade. Upon finishing this walk, they immediately ran at seven miles per hour at the same or higher grade for five minutes if physically able. The results of training and experiments indicated a decrease in resting pulse rates of five beats per minute, an increase in efficiency in grade walking and an overall increase in supplying oxygen to the tissues for an increase in work capacity.

Andrew and co-workers (1) were interested in the differences of training effects on athletes and non-athletes. Their subjects were four ice-hockey players who trained six to eight hours per week in regular ice-hockey practice for four months and four non-athletes who trained one hour per day, five days per week, in body building and endurance activities for four weeks. It was found that the training effects were similar but differed in degree. Both groups had a decrease in resting heart rate and the cardiac output responses for a given external workload also decreased.

Moncrieff (13) trained two matched groups of men by two different methods on a bicycle ergometer. One group trained at a steady pace and the other group did interval training at a higher pace. The subjects were pre-tested for maximal work output and then were retested after two, four, and six weeks of training. It was found that both groups improved after four weeks of training and still more by the sixth week, but there was no significant difference between the groups.

By using a short period of exercising (ten days), Durnin, Brockway, and Whitcher (6) attempted to measure whether there was an improvement in physical fitness through training lasting only a short time. They had four groups walking at a steady pace over varied country for different distances (Control, three kilometers per day; Group 1, ten kilometers per day; Group 2, twenty kilometers per day; and Group 3, thirty kilometers per day). The training was in two consecutive periods of five days with a one-day intermission. It was concluded that there was a significant lowering of heart rates in all groups with the group walking twenty kilometers per day having the most improvement.

Durnin and his associates (6) cited Karvonen, et al. as stating that a heart rate of at least 150 beats per minute is necessary during any given exercise or training to obtain beneficial results in lowering the heart rate.

Andrew and associates, in their study regarding the effect of athletic training on cardiac output, made the following statement:

> If cardiac function is a limiting factor in the performance of maximal exercise, then the ability to achieve a given exercise load at a lower cardiac output should confer on the subject an increased maximal exercise capacity. . . Similarly, training will reduce cardiovascular stress at any given sub-maximal exercise load if the flow demands made on the heart are less. (1)

There is some disagreement as to the efficacy of less than maximal training programs. From these studies and research work, it is indicated that training causes a lowering of the resting heart rate and an increase in work output. They indicate a need for further research in improvement in physical fitness through training at submaximal levels.

CHAPTER III

PROCEDURE OF THE STUDY

I. The Subjects

The selection of subjects was on a voluntary basis from men's health and physical education classes at the University of Montana, Missoula. Sixteen men volunteered to be subjects in this study. Twelve of the subjects were active in the training program and the remaining four were control subjects. They were oriented to the purpose of the study, the procedure which they would follow, and also to the importance of their duties in making the study a success (Appendix B). Each subject was given a short period of pre-training on the treadmill so that he would be familiar with walking on the apparatus. The training groups trained at heart rate levels of 120, 150, or 180 beats per minute as indicated in Table I. The physical characteristics of the subjects are shown in Appendix C and the training group means are shown in Table I.

TABLE I

MEAN PHYSICAL CHARACTERISTICS OF THE SUBJECTS

Groups	$\bar{X}$ Height in inches	$\bar{X}$ Weight in pounds	$\bar{X}$ Age in years
Control	70.500	156.00	20.00
120	70.375	162.75	18.25
150	71.375	153.25	18.00
180	71.250	161.75	18.25
Total means	70.875	158.4375	18.625

II. Equipment and Apparatus

Treadmill

The treadmill was a motor-driven apparatus with a continuous rubber belt eighteen feet, five inches long and four feet wide. There were two eight-inch end rollers around which the belt revolved and forty-two, two-inch bed rollers which served as a support and smooth walking surface for the subjects.

The speed of the treadmill was adjusted by varying the belt tension. In this study, it was held constant at three and one-half miles per hour. The speed was recorded on a speedometer which was calibrated in yards per minute.

The inclination of the treadmill was controlled manually by a crank at one end of the apparatus which raised and lowered the angle of the walking surface from level grade to fifty-one per cent grade. This could be done while the treadmill was running. By experiment, it was found that three turns of the crank raised or lowered the grade of the treadmill by one per cent (11). Before the study was conducted, the treadmill was calibrated for accuracy in speed and grade of elevation.

Radio-Electrocardiograph

A Telemedics RKG 100-electrocardiograph system was used to measure heart rates of the subjects as they trained on the treadmill. The equipment which made up the system was: a pair of special electrodes, a small battery-operated transmitter, and a portable radio receiver used to forward the characteristic EKG waves to the recording equipment.

The electrodes. The electrodes consisted of an adhesive moleskin patch with electrode paste reservoir and a gripper-type fastener to connect the electrode to the flexible wires. These electrodes were placed on the right and left fifth ribs slightly forward of the axillary region.

The radio transmitter. The small transmitter strapped to the body was one inch thick, three inches wide, and four inches high. The unit weighed ten ounces, including the batteries. The heart beat was carried by thin flexible wires from the electrodes to the transmitter which radioed the heart rate to the radio-electrocardiograph by way of the receiving antenna.

The radio receiver. The portable desk model receiver was operated from a standard electrical power line. The receiver contained a channel selector which channeled the

EKG waves to the recording instrument.

The recording instrument. A Telemedics Cardiotac 400 R electrocardiograph recording device was used. The EKG signals were relayed through a meter where the heart rate was continually indicated in beats per minute. The heart rate was amplified as an audible "beep" so that one could count the beats per minute. There was a volume control for setting the audio level. This instrument was calibrated each day before training sessions for accuracy in recording.

Electrocardiograph

A Burdick EK-2 Direct-recording electrocardiograph instrument was used to obtain an accurate reading of the resting heart rate of each subject during the first and last weeks of training. The heart rate was recorded three times at one-minute intervals after the subject had been in a reclining resting position for at least ten minutes.

III. Testing and Training Schedule

The testing and training sessions were held during the Fall Quarter, 1965, in the Human Performance Laboratory on the University of Montana campus.

After the first day of orientation and pre-training, each subject was given a pre-test which consisted of a simple step test and an optimal capacity test involving walking on the treadmill. The control group was administered the same two pre-tests and then questioned two or three times during the training period concerning their activities.

The step test used was the Astrand-Rhyming Step Test, which required the subject to step up onto a step bench forty centimeters high at the rate of 22.5 steps per minute as indicated by a metronome. Each full cycle of stepping up and back down took four beats to complete (i.e. two beats up, two beats down). The test lasted for five minutes. Prior to the test, the subject had electrodes affixed to his body and the transmitter strapped on. Following a ten-minute rest period, a resting heart rate was taken in the sitting position and then at the end of the test, a recovery rate was taken from ten seconds to twenty-five seconds. The Astrand-Rhyming Step Test was scored by using the heart rate during the last minute of the test and the body weight in kilograms. This was plotted on a nomogram to obtain the score (2). This test attempts a prediction of a subject's aerobic capacity.

Following the submaximal step test and completion of a ten minute rest period, the subject started the optimal work capacity test. The test used was the Treadmill Test of Optimal Capacity by Balke (4). This test required the subject to walk at a rate of three and one-half miles per hour on the treadmill. For the first minute of the test, the angle of the treadmill was at level grade and was raised to two per cent at the end of that time; then one per cent each minute until the subject's heart rate reached 180 beats per minute. At that time, the test was terminated and the subject's recovery heart rate was taken from thirty seconds to forty-five seconds while the subject sat quietly. The test results were scored by the number of minutes the subject walked on the treadmill until the heart rate reached 180 beats per minute.

Training Protocol

The subjects were scheduled to train three times a week for six weeks. They were instructed to report for training in gym shorts and tennis shoes. The training sessions were held in the morning hours and each subject was asked not to eat or drink for two to three hours prior to each session.

Upon arrival at the laboratory, the subject weighed himself and affixed the electrodes to his body. He then reclined on a table and answered a few questions concerning amount of sleep, last food and liquid taken (other than water) and amount of activity since the last training session. His oral temperature was also taken and recorded. A sample data sheet may be found in Appendix A. The subject then prepared to train. The training on the treadmill lasted for ten minutes during which time the subject's heart rate was increased to his training level within the first two minutes by raising the angle of the treadmill's walking surface. The subject's heart rate was kept steady during the remaining eight minutes by raising or lowering the grade. When the walk was completed, the subject sat down and a recovery rate was taken from thirty seconds to forty-five seconds. The electrodes and transmitter were then removed and the subject was finished with his training session.

The choosing of heart rate training levels was on the basis that one be an easy level (120 beats per minute), one a moderate level (150 beats per minute), and one a difficult level (180 beats per minute). The grade of the treadmill was started at different levels to make it easier to reach the subject's heart rate training level. The subjects' heart rate training levels and starting grades of the treadmill are shown in Appendix D. Halfway through the study (after eight training sessions), the treadmill starting grades were increased by five per cent as it became more difficult to get the subjects' heart rates up to their training levels. The assigning of heart rate levels to the subjects was taken from a table of random numbers so that no bias was operating in the assignment of training levels.

Throughout each daily training session, a close check was made of the temperature, barometric pressure, and relative humidity of the laboratory. These were recorded along with other details pertaining to the study.

Upon completion of the sixteen training sessions, each subject was post-tested using the same tests given in the pre-tests. The control subjects were also tested after being reoriented to the treadmill.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

I. Introduction

The following chapter presents the analysis of the data obtained from the experiment involving training at varying heart rate levels to see if training at a submaximal heart rate level would increase one's physical fitness substantially. This data can be found in Tables II-VII, and will be discussed later in this chapter.

II. Analysis of Results

It was of interest to determine if training at the various heart rate levels would prompt changes in the subjects' resting heart rates. An average of the first three days and the last three days of training was taken and it was found that the 120 heart rate group and the 180 heart rate group as well as the control group improved (heart rate dropped in beats per minute). The control group's resting heart rate was taken only on the first and last days of the training period. The 150 heart rate group's pulse rate increased slightly. The results are shown in Table II.

TABLE II

AVERAGE RESTING HEART RATE CHANGES DUE TO TRAINING

Heart rate level	Heart rate average (first three days)	Heart rate average (last three days)	Difference
Control	70.5	69.8	-0.7
120	71.4	65.0	-6.4
150	80.1	81.7	+1.6
180	71.1	68.9	-2.2

From the training levels used, it was expected that the 180 heart rate group would improve the most and the other levels would follow according to their degree of intensity. The results of the heart rate changes indicate that the control group had the least amount of improvement and the 120 heart rate group improved the greatest amount. This could be due to the fact that some of the subjects in the 120 heart rate group were more active than others and participated in outside activities which increased their training load.

Comparison of Pre-test and Post-test Results of the Balke Test

In the Balke Test of Optimal Capacity, the difference between the pre-test and post-test scores indicated that the control group decreased in optimal capacity while the training groups remained the same or increased (Table III). This pointed out that the training intensities were such that the 120 heart rate group did not have enough intensity in their training to warrant a change in work capacity as measured by the Balke Test. The two higher intensity groups increased as the result of training.

TABLE III

COMPARISON OF MEAN DIFFERENCES OF PRE-POST TEST SCORES

Groups	Balke mean difference	Step Test mean difference
Control	-0.25	+0.625
120	0.00	+2.150
150	+1.25	+0.075
180	+3.75	+6.675

The analysis of variance procedure was used to determine if there was a significant difference between the group means in the Balke Test (Table IV). The F-ratio on the analysis of variance test was significant beyond the .01 level of confidence. To obtain a .01 level of confidence, the F-ratio needed to be 5.42. The analysis of variance formulae are shown in Appendix G.

TABLE IV

ANALYSIS OF VARIANCE FOR BALKE TEST

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-ratio
"Between" groups	3	42.438	14.146	
"Within" groups	12	25.000	2.083	6.79*
Total	15	67.438	4.496	

*Significant beyond the .01 level of confidence

<u>Hartley Test for Significance Within the Balke Test</u>

To test for the location of significant difference within the Balke Test, the Hartley Test was conducted. This test indicated significance at the .05 level of confidence. The test indicated where there was a significant difference at the .05 level of confidence (Table V). The numbers that appear in parentheses in the table are the least significant differences as discussed in Snedecor (15). If this number is less than the mean of one group minus the mean of the comparison group, it is significant. Therefore, the numbers with the asterisk (*) indicate significance. The formula for calculating the Hartley Test is found in Appendix G. The significant differences within the Balke Test were between the 180 heart rate group and the other groups and also between the 150 heart rate group and the groups below that level (120 heart rate group and control group).

TABLE V

HARTLEY TEST FOR SIGNIFICANCE WITHIN THE BALKE TEST

Heart rate group	$\bar{X}$	$\bar{X}$-(-.25)	$\bar{X}$-.00	$\bar{X}$-1.25
180	3.75	4.00* (0.76)	3.75* (0.68)	2.50* (0.56)
150	1.25	1.50* (0.68)	1.25* (0.56)	
120	0.00	0.25 (0.56)		
Control	-0.25			

*Indicates significance

Comparison of the Pre-test and Post-test Results of the Step Test

In the Step Test, the data was somewhat similar to the results of the Balke Test. The differences were highly significant at the .01 level of confidence although the difference in predicted maximum oxygen capacity of the 150 heart rate group did not improve as much as the control group. The high level of confidence was indicated by another analysis of variance test which was conducted to determine the significant difference between the means of the Step Test. These results are shown in Table VI and the analysis of variance formulae may be found in Appendix G.

TABLE VI

ANALYSIS OF VARIANCE FOR STEP TEST

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-ratio
"Between"groups	3	107.572	35.875	
"Within"groups	12	51.173	4.264	8.41*
Total	15	158.745	10.583	

*Significant beyond the .01 level of confidence

The 120 heart rate group increased more than the 150 heart rate group as two members of the low-intensity group participated in active sports (intramurals) and in popular dances. They were supposed to remain inactive except for normal daily activities and their training sessions on the treadmill. It was unfortunate that the two breaches of training regulations should occur in the same group.

Hartley Test for Significance Within the Step Test

The Hartley Test was used again to test for the location of significant differences between the means of the Step Test (Table VII). The significant differences within the Step Test were different from those in the Balke Test. These differences were between the 180 heart rate group and all the other groups as well as significant differences between the 120 heart rate group and the control group and the 150 heart rate group.

TABLE VII

HARTLEY TEST FOR SIGNIFICANCE WITHIN THE STEP TEST

Heart rate group	$\bar{X}$	$\bar{X}$-.075	$\bar{X}$-.63	$\bar{X}$-2.15
180	6.675	6.600* (1.063)	6.045* (0.978)	4.520* (0.802)
120	2.150	2.075* (0.978)	1.520* (0.802)	
Control	0.630	0.555 (0.802)		
150	0.075			

*Indicates significance

III. Discussion of Results

The results of this study indicate that by training at near maximal heart rate levels, one could increase his work capacity. Durnin and his associates (6), found that improvement in fitness could be elicited from training for only a short length of time. In a study conducted by Maxfield (13), training over a period of weeks brought about a change in work capacity and a decrease in heart rate both at work and at rest. Knehr, Dill, and Neufeld (10) obtained similar results from their study, but their training period lasted for six months. Erickson and associates (7) felt that training effects may take weeks to arrive at a high level of fitness. This study showed that there was an increase in cardiorespiratory fitness, but much more training would be necessary for high-level fitness.

A linear correlation between the pre-tests of the treadmill test and the step test showed that a high relationship (.81) existed (8). The coefficient of correlation formula may be found in Appendix G. This relatively high correlation helps to substantiate the use of these tests for studies in optimal work capacity and heart rate measures. Since both tests utilize the heart rate as a criterion of work capacity of fitness, it would be expected that they would offer somewhat similar results.

The differences obtained from the pre-test and post-test scores on the Balke Test follow a sequence of increasing improvements as would be expected from the increasing intensities of training. The means for the training intensities of the test were significantly different beyond the .01 level of confidence.

A further test was made (the Hartley Test), to show where the significant differences were within the test. The differences were found between the 180 heart rate group and the other groups. The 150 heart rate group was also significantly different from the 120 heart rate group and the control group.

The results of the Step Test proved to be slightly different. The pre-test to post-test differences indicated that the control group showed greater improvement in fitness than the group that trained for six weeks at 150 heart beats per minute. This may have been due to the fact that one subject in the 150 heart rate group did not do any activity other than the training itself. The other subjects were active as was expected. Two men in the 120 heart rate group were overactive and indulged excessively in popular dances and sports. The means were significant at the .01 level of confidence. The Hartley Test was conducted again to show where the significant differences were within the test. Hartley's Test indicated that there was a significant difference between the 180 heart rate group and the other groups. There was also significant difference between the 120 heart rate group and the control and 150 heart rate groups.

These results would indicate the need for a high-intensity heart rate level at which to train for any substantial increase in physical fitness.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. Summary

This study was conducted to determine if subjects could train at a submaximal heart rate level to increase their physical fitness. Sixteen students enrolled in physical education activity classes at the University of Montana volunteered to participate as subjects in an attempt to evaluate the success of such a training program.

Each subject was given a step-test to predict the aerobic capacity and also a treadmill test of optimal capacity as pre-tests before they participated in a training period. The subjects trained three times per week for six weeks at various heart rate levels. Their pulse rates were taken each training day following a recumbent rest period.

Upon completion of the training period, the subjects were administered the same step-test and treadmill test as a post-test to obtain results as to the effectiveness of the training programs.

A linear correlation was run on the pre-test results of the step-test and treadmill test and it was found to have a correlation of .81 to suggest a common element within the two tests. This might be expected, since both tests utilize the response of the heart as a criterion measure. An analysis of variance test was used to test the hypothesis that there was no difference between the means of the differences between the pre- and post-tests. The analysis of variance on the treadmill test data indicated that there was a highly significant difference between the means. The results of the analysis of the step-test also showed a highly significant difference in the means. The differences in both of these tests were significant beyond the .01 level of confidence.

A further test of significance was conducted to determine the location of significant differences as measured by the Balke Test and step-test. This test, the Hartley Test, indicated that to increase physical fitness significantly, the subjects had to work at a high-intensity level, which was the 180 heart rate group in this study.

II. Conclusions

On the basis of the results found in this study, the following conclusions were made:

1. There is a highly significant linear relationship between the use of the Astrand-Rhyming Step Test and Balke's Treadmill Test.
2. To obtain significant results in physical fitness, the training would have to be at a high-intensity level.

3. The training programs used were either too brief or of too low an intensity to produce substantial change in the resting heart rate.

III. Recommendations

In view of the findings and conclusions from this study, the following recommendations have been made:

1. Further studies should be conducted on the range of 150 to 180 heart beats per minute.
2. In future research, it would be profitable to use more subjects in each group and possibly to use subjects of known fitness levels for easier interpretation of results.
3. More control over the subjects regarding their activities, sleeping, nutritional, and general health habits is desirable for more accurate and precise training results in future studies conducted in this area of interest.
4. More definitive work is needed to substantiate the use of specific tests of cardiorespiratory endurance.

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APPENDIX

APPENDIX A

HUMAN PERFORMANCE LABORATORY

Subject__________________ Date____________ Treatment_____________

Control Data: Rm Temp____Bar Pr____Rel Hum____Oral Temp________

Bdy Wt____Ht___Resting Pulse____ ____ ____ ____Bl Pr____________

Last Food______Drink (not H_2O)_______Hrs Slp___Last Ex__________

Other____

Experimental Data:

____

____

____

____

Ventilation: Gasometer factor (GF)__________Meter factor_______
Conversion factor (derived from bar pr and temp of gas) -CF

Post

____-____=____x GF =____x CF =____/min. =____VR (L/min.)
____ ____ ____ ____ ____ ____
____ ____ ____ ____ ____ ____

Gas Analysis:

	T1	T2	$\overline{X}$	RQ	T-O_2		VR			cO_2/min.
CO_2	______	______	______	____	______	x	______	=	___/100=	____________
O_2	______	______	______	____	______	x	______	=	___/100=	____________
	______	______	______	____	______		______		___	____________
	______	______	______	____	______		______		___	____________

Comments:

APPENDIX B

Gentlemen:

We appreciate your cooperation in this experiment. To insure that our combined efforts are not wasted we ask you to do your best to comply with a few necessary regulations. Since this is an evaluation of training effects it is imperative that you avoid strenuous exercise, especially that which would prompt rapid breathing and heart rates. We further ask that you be as accurate as possible when completing the short daily questionnaire, particularly the items referring to prior exercise and general health.

Try to keep training appointments and we will do our best to keep them brief. If, for reason of illness, accident, etc., you cannot come, do let us know.

The daily (M-W-F or Tu-Th-S) training schedule will be:

0:00 Subject arrives in shorts, tennis shoes and takes weight. Electrodes affixed.

0:05 Subject begins rest period - during rest oral temperature taken, questionnaire completed.

0:15 Resting pulse taken. (3x)

0:19 Prepare to Exercise.

0:20 Exercise begins.

0:30 Exercise terminated - recovery begun.

0:33 Recovery period completed.

We are looking forward to working with you and hope you will feel free to discuss aspects of the project that interest you.

Sincerely,

J. P. Holleman
Dr. Brian J. Sharkey
Department of Health,
Physical Education and Athletics

APPENDIX C

PHYSICAL CHARACTERISTICS OF THE SUBJECTS

Subjects	Height in inches	Weight in pounds	Age in years
H.A.	68.0	134	18
C.B.	72.0	173	19
D.B.	70.5	155	18
J.B.	70.5	158	18
P.C.	70.0	151	18
P.D.	73.0	147	18
M.E.	73.0	168	18
L.E.	72.0	153	18
W.F.	71.0	148	18
J.G.	71.0	202	18
L.H.	72.0	157	19
G.K.	68.5	150	18
R.R.	71.0	170	18
D.S.	72.0	162	19
D.W.	70.0	174	23
N.W.	69.5	133	20
MEANS	70.875	158.438	18.625

APPENDIX D

SUBJECT'S TRAINING LEVELS AND TREADMILL STARTING GRADES

Subjects	Training Levels (beats per minute)	% of Starting Grades (first eight sessions)	(last eight sessions)
H.A.	120	0	5
C.B.	180	10	15
J.B.	120	0	5
P.C.	180	10	15
P.D.	150	5	10
M.E.	150	5	10
L.E.	180	10	15
W.F.	150	5	10
J.G.	120	0	5
L.H.	120	0	5
G.K.	150	5	10
R.R.	180	10	15

APPENDIX E

BALKE TEST

Control Group

Subjects	Pre-test (minutes)	Post-test (minutes)	Difference
N.W.	14	14	0
D.S.	13	12	-1
D.B.	17	17	0
D.W.	16	16	0
Means	15	14.75	-.25

120 Heart Rate Group

Subjects	Pre-test (minutes)	Post-test (minutes)	Difference
H.A.	16	15	-1
J.B.	15	15	0
L.H.	17	17	0
J.G.	9	10	+1
Means	14.25	14.25	0

150 Heart Rate Group

Subjects	Pre-test (minutes)	Post-test (minutes)	Difference
G.K.	7	8	+1
P.D.	16	17	+1
M.E.	13	14	+1
W.F.	13	15	+2
Means	12.25	13.50	+1.25

180 Heart Rate Group

Subjects	Pre-test (minutes)	Post-test (minutes)	Difference
C.B.	16	17	+1
R.R.	12	15	+3
P.C.	16	24	+8
L.E.	13	16	+3
Means	14.25	18.00	+3.75

APPENDIX F

STEP TEST

Control Group

Subjects	Pre-test	Post-test	Difference
N.W.	43.0	43.0	0
D.S.	44.3	46.6	+2.3
D.B.	46.9	46.9	0
D.W.	48.2	48.4	+0.2
Means	45.6	46.225	+0.625

120 Heart Rate Group

Subjects	Pre-test	Post-test	Difference
H.A.	47.1	51.8	+4.7
J.B.	42.5	46.6	+4.1
L.H.	52.9	51.5	-1.4
J.G.	34.6	35.8	+1.2
Means	44.275	46.425	+2.15

150 Heart Rate Group

Subjects	Pre-test	Post Test	Difference
G.K.	31.3	31.2	-0.1
P.D.	54.2	51.7	-2.5
M.E.	33.6	34.8	+1.2
W.F.	40.9	42.6	+1.7
Means	40.0	40.075	+0.075

180 Heart Rate Group

Subjects	Pre-test	Post-test	Difference
C.B.	48.6	57.0	+8.4
R.R.	36.2	42.7	+6.5
P.C.	38.9	46.9	+8.0
L.E.	38.9	42.7	+3.8
Means	40.65	47.325	+6.675

APPENDIX G

STATISTICAL ANALYSIS

Formula for Correlation of Pre-tests on the Balke and Step Tests:

$$r = \frac{\Sigma xy}{N\sigma x\sigma y}$$

where:

r = coefficient of correlation when deviations are taken from the means of the two distributions

Σxy = sum of the product of deviations taken from the mean

N = number of subjects in sample

σx = standard deviation of test X

σy = standard deviation of test Y

Analysis of Variance Formula:

Total sum of squares -

$$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{N}$$

where:

Σx^2 = total sum of squares

ΣX^2 = sum of the square of the group scores

$(\Sigma X)^2$ = sum of the individual scores squared

N = number of subjects in sample

APPENDIX G (CONT'D)

The "Between" Sum of Squares Formula:

$$\Sigma x^2 = \frac{(\Sigma X)^2}{n} - \frac{(\Sigma X_T)^2}{N}$$

where:

Σx^2 = "between" sum of squares

$\frac{(\Sigma X)^2}{n}$ = total sum of the square of the individual scores divided by the number of subjects in each training group

$\frac{(\Sigma X_T)^2}{N}$ = sum of the total scores squared divided by the number of subjects in the sample

The "Within" Sum of Squares Formula:

$$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$$

where:

Σx^2 = "within" sum of squares

ΣX^2 = sum of squares of the group scores

$\frac{(\Sigma X)^2}{n}$ = sum of the square of the individual scores divided by the number of subjects in each training group

The F-Test:

F = mean square for "between" groups divided by the mean square for "within" groups

APPENDIX G (CONT'D)

Hartley Test for Comparison Among Means Formula:

$$D = \sqrt{\frac{\text{Error Mean Squared}}{a(a - 1)/2}}$$

D = square root of the sum of the error mean squares divided by total possible combinations of (a) things taken two at a time

D is then multiplied by the respective Q's (taken from table, 15) based on the differences in rank order, to arrive at the least significant difference for comparison with each mean difference.